

Quick Drought Response Index (QuickDRI)

A Composite Index for Monitoring Short-Term Dryness Conditions

Brian Wardlow

**Center for Advanced Land Management Information Technologies (CALMIT)
University of Nebraska-Lincoln**

Project investigators: Mark Svoboda¹, Tsegaye Tadesse¹, Jesslyn Brown², Martha Anderson³,
Chris Hain⁴, Matt Rodell⁵, and David Mocko⁵

¹National Drought Mitigation Center (NDMC), University of Nebraska-Lincoln

²USGS Center for Earth Resources Observation Science (EROS)

³USDA Agricultural Research Service (ARS)

⁴NASA Marshall Flight Center

NASA Goddard Space Flight Center (GSFC)

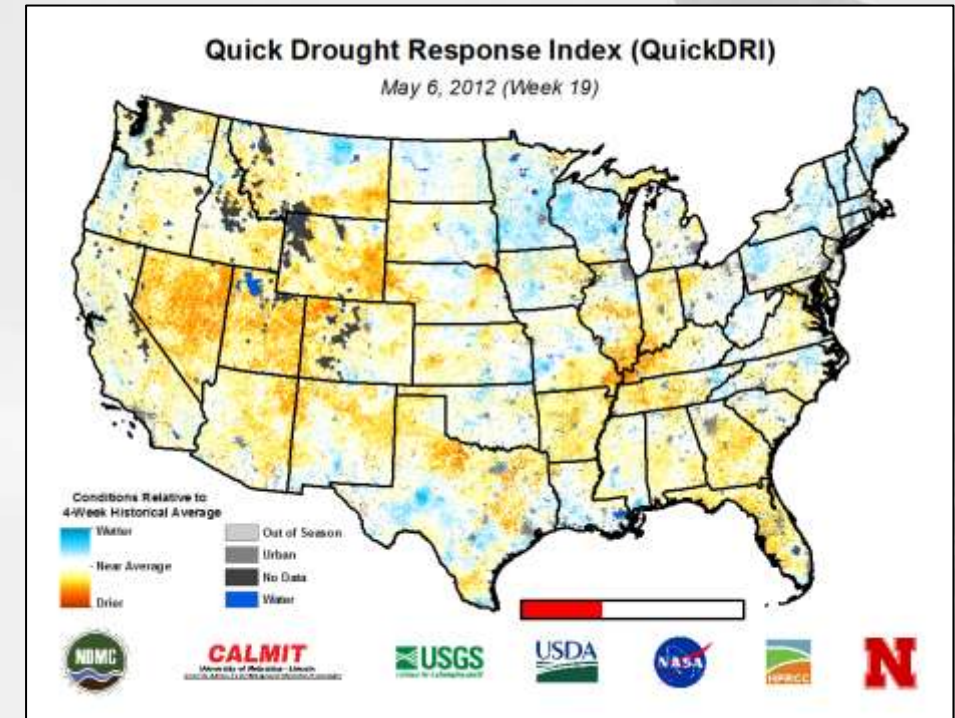
*2018 North American Drought Monitor Forum
Calgary, Alberta, Canada
May 1-3, 2018*



Quick Drought Response Index (QuickDRI)

QuickDRI is a ‘composite’ drought index that monitors rapid, short-term changes in landscape-level dryness for drought monitoring through the integration of information related to:

- vegetation conditions
- evapotranspiration (ET)
- root-zone soil moisture
- precipitation using climate-based drought index data
- biophysical characteristics of the environment



Goal: Characterize shorter-term dryness conditions on the order of weeks to a month to detect the onset of drought and rapidly developing flash droughts.

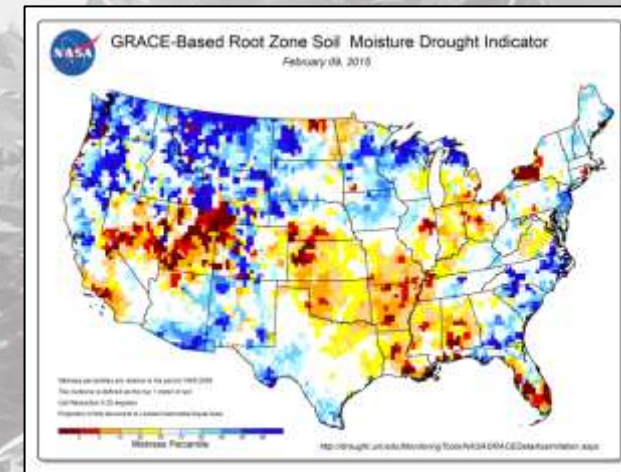
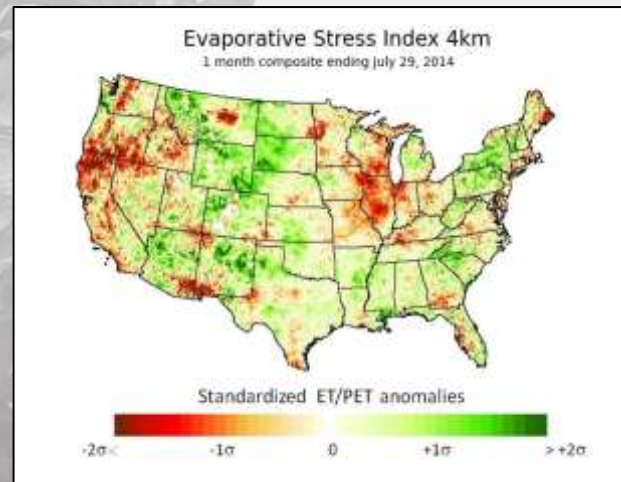
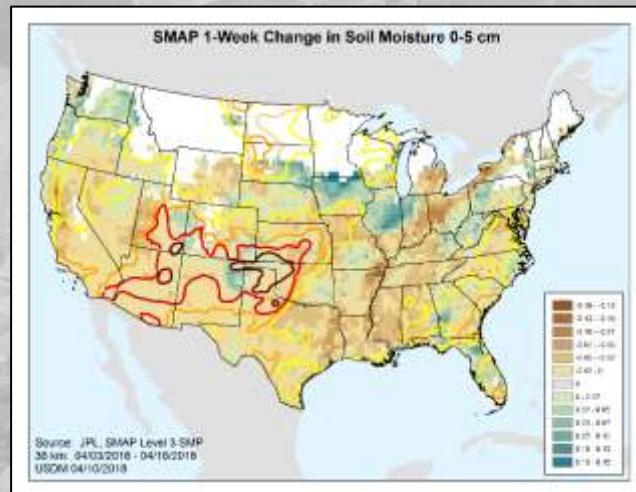
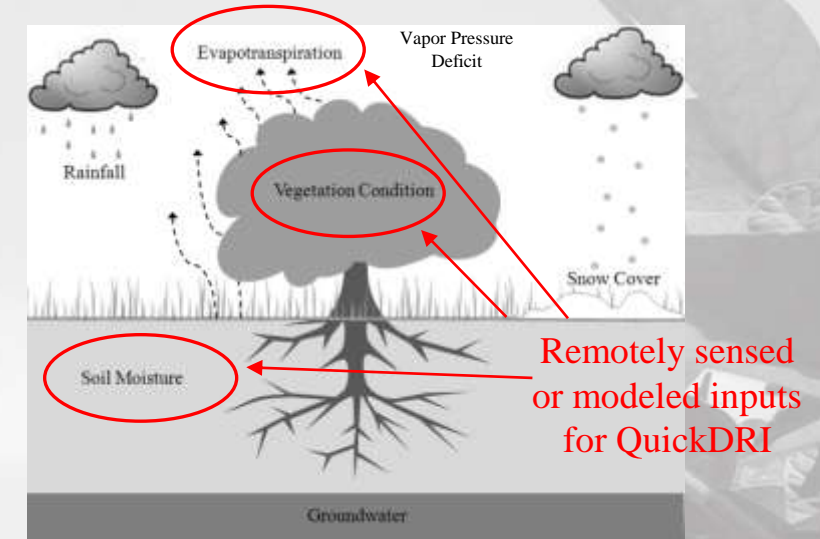
NASA supported research project that transitioned from research to an operational monitoring tool in the summer 2017 producing **1-km QuickDRI gridded data and maps on a weekly basis over the continental United States.**

Advances in Remote Sensing Tools for Drought Monitoring

Since the early 2000s, **many satellite remote sensing-based tools have been developed** characterizing different parts of the hydrologic cycle that influence drought conditions.

Catalysts:

- New satellite sensors and types of observations
- Extend 10+ year historical image data record
- Advancements in modeling and statistical analysis
- Improved computing capabilities

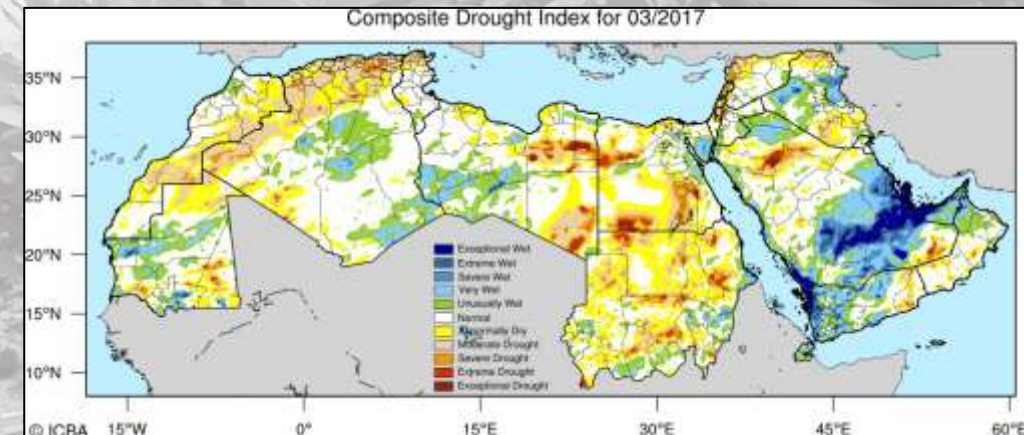
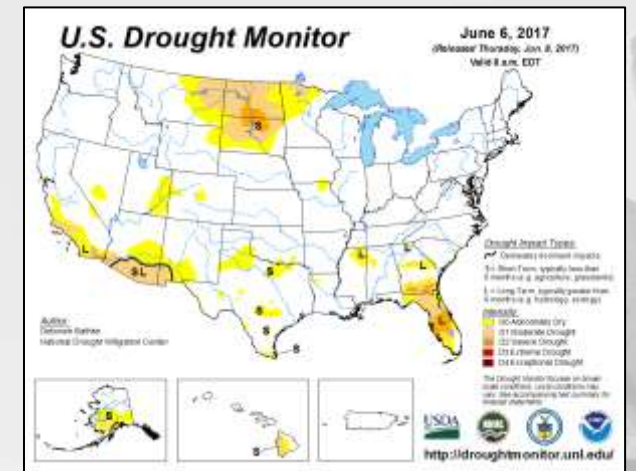


Emergence of ‘Composite’ Drought Indicators

- Traditional drought indicators are designed to monitor a specific environmental parameter (e.g., precipitation, soil moisture, and temperature) and have their own relative strengths and weaknesses.
- Increased emphasis on the development of **‘composite’ drought indicators that combine different types of information/drought indicators in a single index value.**

Goals:

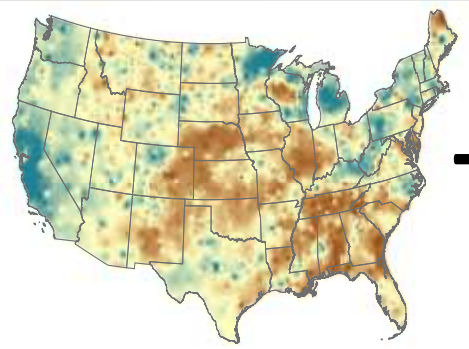
- Leverage strengths and unique information provide by different indicators.
- Provide a more complete characterization of drought conditions in a single indicator.



Quick Drought Response Index (QuickDRI)

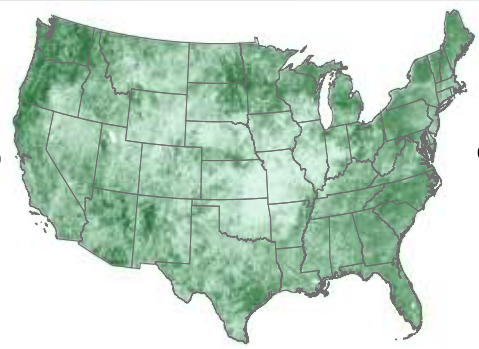
QuickDRI is a 'composite' drought index that monitors rapid, short-term changes in drought conditions through the integration of:

Precipitation



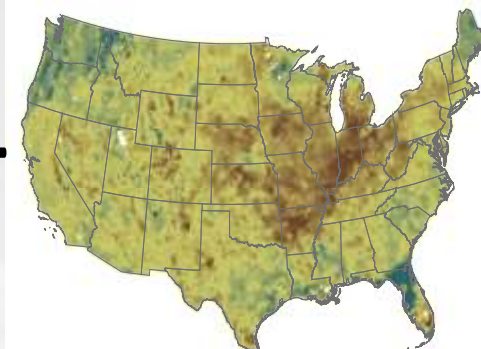
+

General Vegetation Health



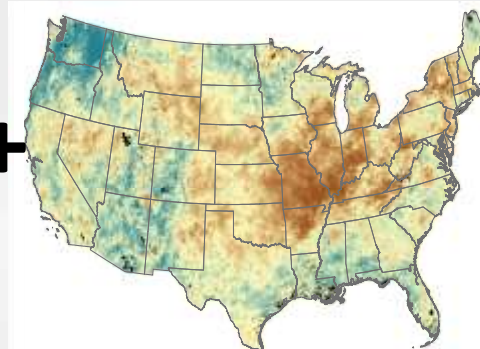
+

Root-zone Soil Moisture



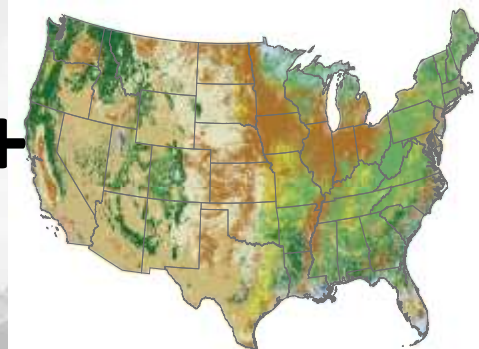
+

Evapotranspiration (ET)



+

Other Environmental Characteristics



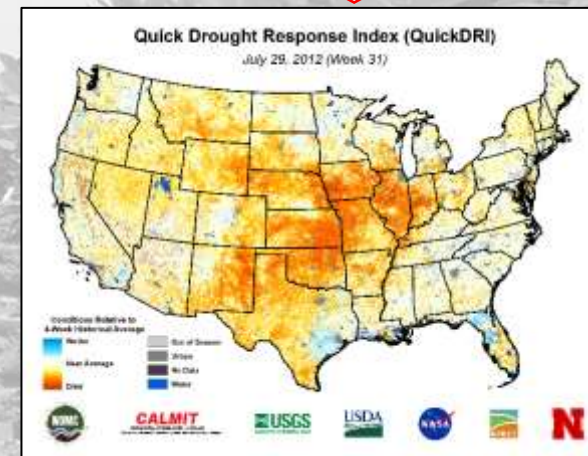
- 4-week Standardized Precipitation Index (SPI)

- Standardized Vegetation Index (SVI)
- 1-month, root-zone soil moisture anomaly from VIC

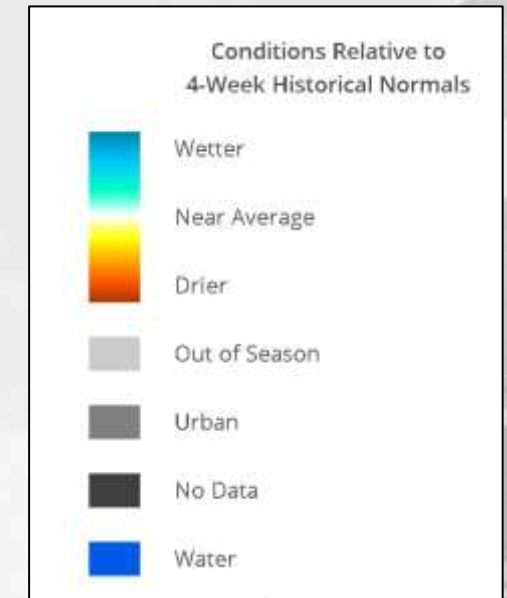
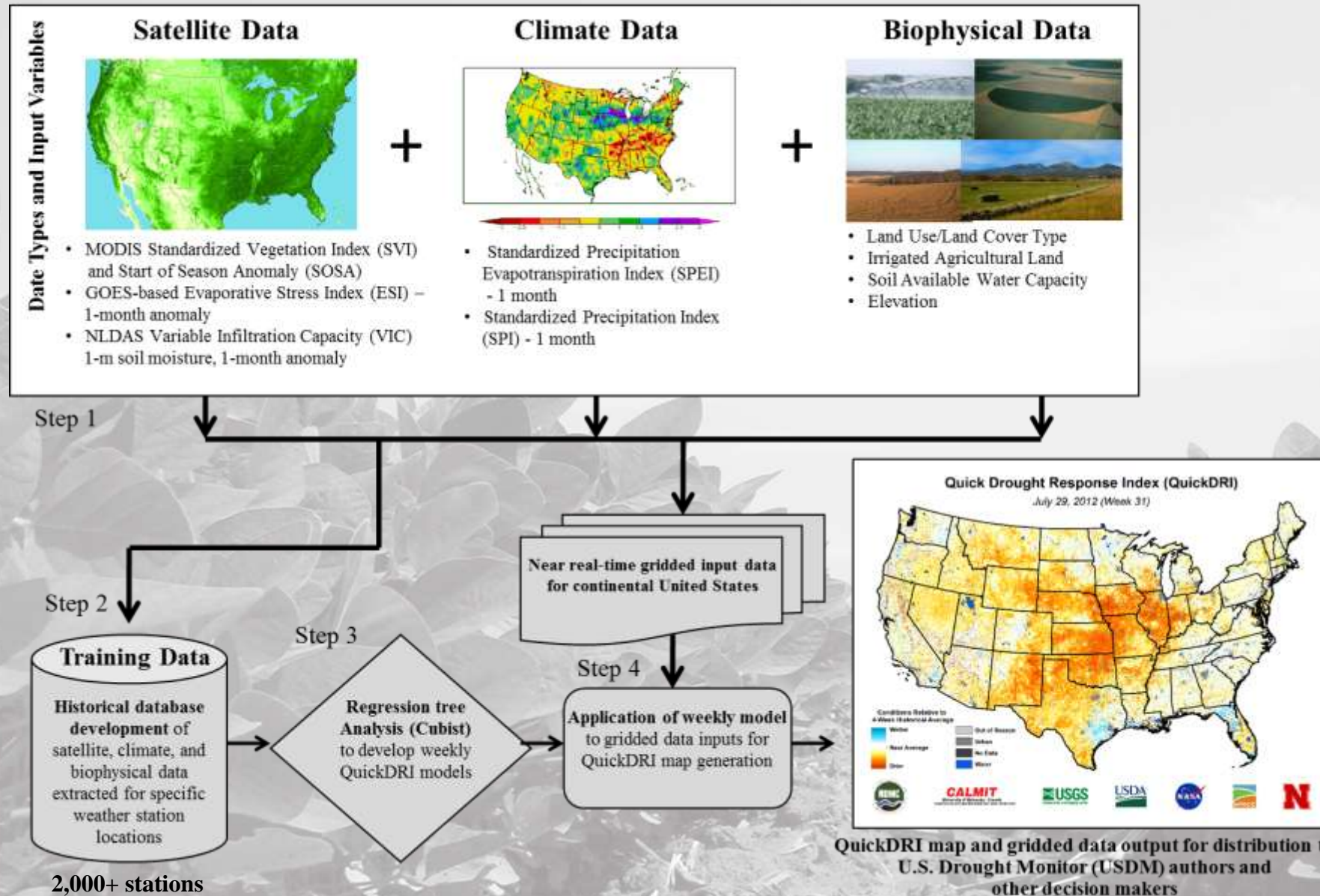
- 1-month Evaporative Stress Index (ESI)

- Land use/land cover
- Irrigation
- Soil available water holding capacity
- Elevation
- Start of season anomaly

Goal: Use recently available remote sensing products that are shorter-term indicators of drought-related environmental conditions to develop a composite drought index that **characterizes shorter-term and rapidly developing changes in landscape-level dryness signaling the emergence/end of drought or rapid changes in drought severity.**



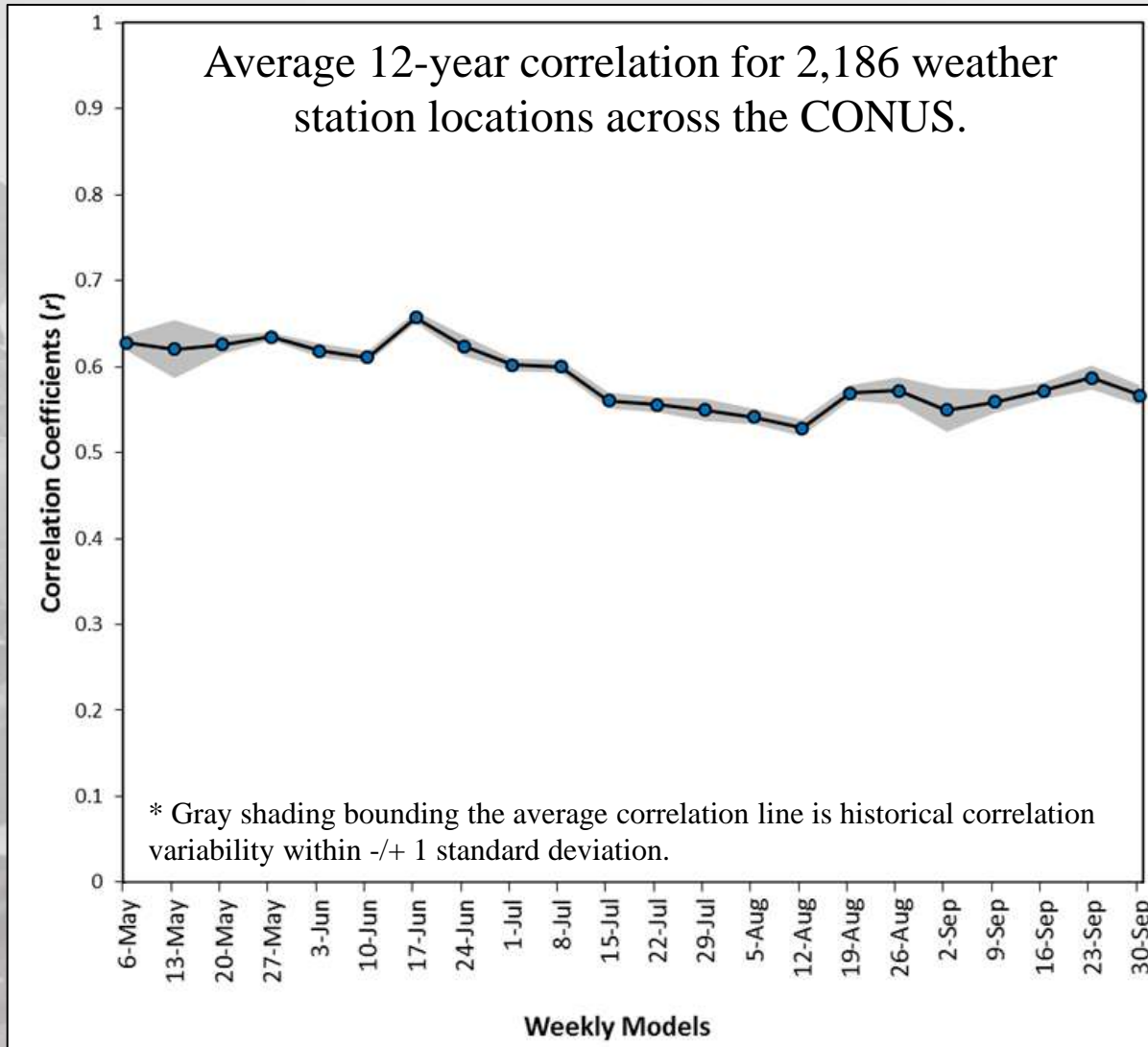
QuickDRI Methodology



QuickDRI Dryness Scale

- **SPEI value range** is used to scale relative landscape dryness across a 'wetter-near average-drier' continuum.
- 'No Data' marks **areas where data for a specific input variable (e.g., ESI) was not available** for a given date.
- 'Out of Season' is **applied during the winter months (Dec.-Feb.)** to avoid anomalous dryness signals in QuickDRI from snow cover.

12-Year Statistical Analysis of Weekly QuickDRI Models



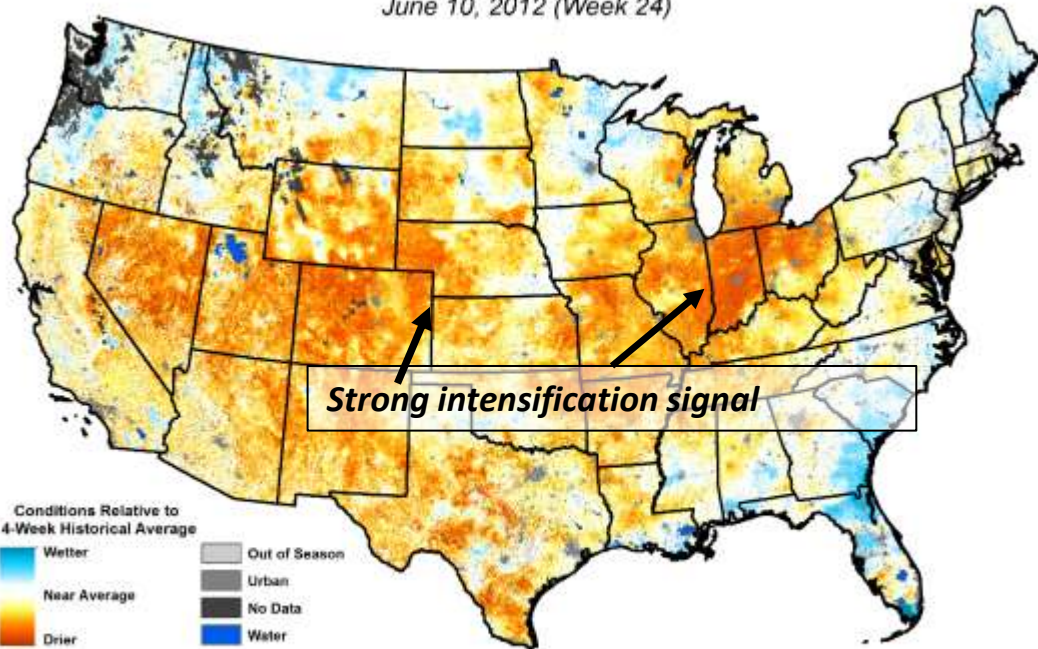
- **Weekly correlation values ranged from 0.55 to 0.69** across the growing season over the continental U.S. (CONUS).
- **Slightly higher correlations for the early growing season periods (May – June).**
- **Imperfect relationship may be expected** given the observed SPEI is calculated from precipitation and air temp. data vs. the calculated QuickDRI value on the SPEI scale, which is calculated from precipitation, land surface temp., soil moisture, and vegetation greenness data.
- **Historical variability in the weekly, predicted QuickDRI values is low** indicating relatively stable model performance across the year.

QuickDRI During 2012 Drought

Rapid Onset of Drought Conditions

Quick Drought Response Index (QuickDRI)

June 10, 2012 (Week 24)



Strong intensification signal

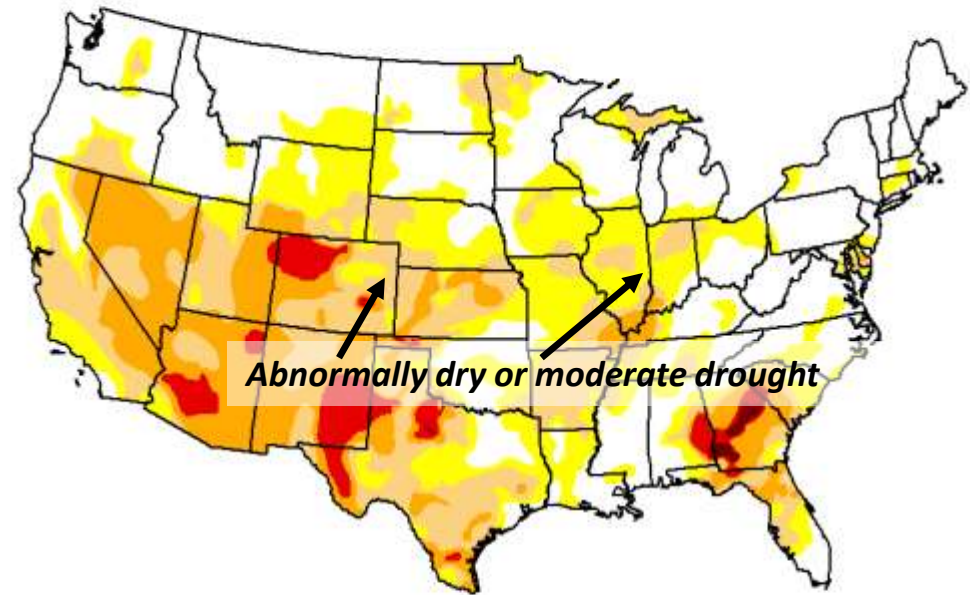


CALMIT
University of Nebraska - Lincoln
Center for Advanced Land Management Information Technologies



U.S. Drought Monitor CONUS

June 12, 2012
(Released Thursday, Jun. 14, 2012)
Valid 7 a.m. EST



Intensity

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

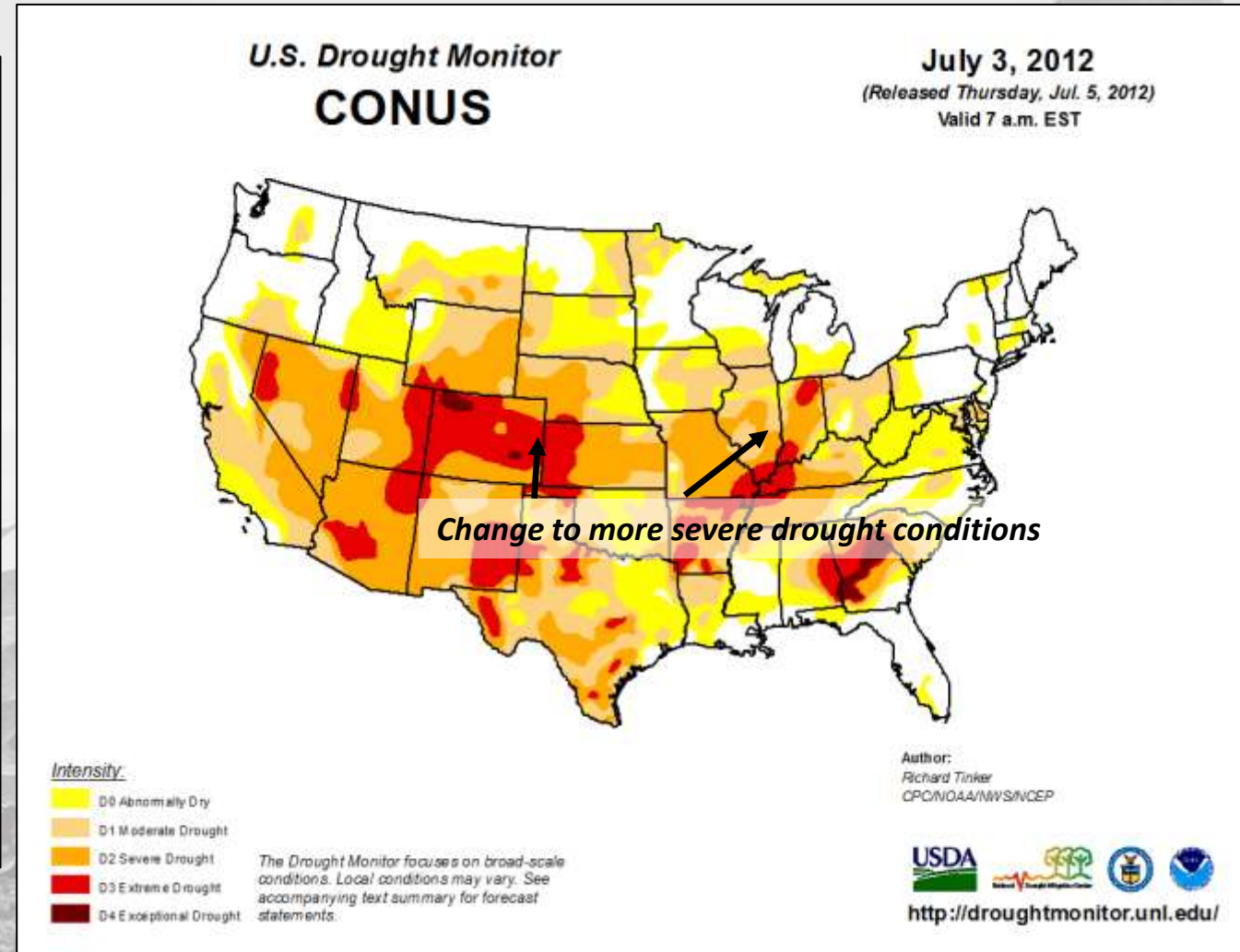
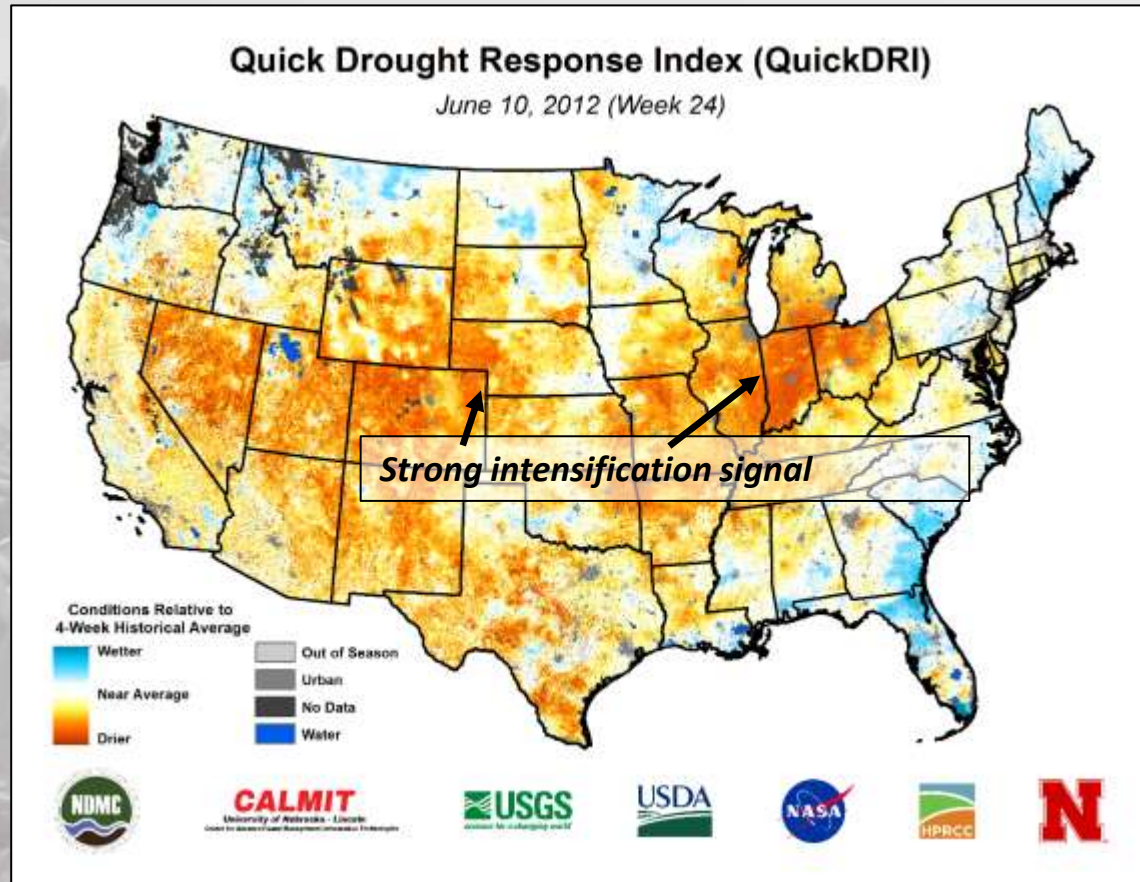
Author:
David Miskus
NOAA/NWS/NCEP/CPC



<http://droughtmonitor.unl.edu/>

QuickDRI During 2012 Drought

Rapid Onset & Intensification of Drought Conditions



QuickDRI – 2017 Drought in Northern Great Plains

- QuickDRI detected moderate to very dry areas of the Dakotas, eastern Montana and northwest Minnesota **two to three weeks (May 16 and 23) prior to the USDM changing D0 and D1 locations to more severe drought intensity classes by early June.**
- State drought advisory committee in Montana used QuickDRI as an additional **information source to recommend a drought declaration for counties in eastern Montana to the Governor.**

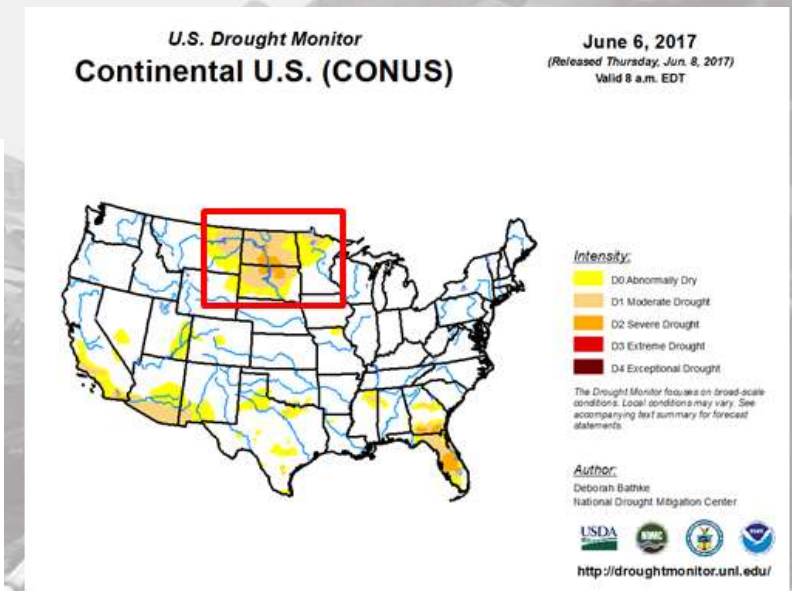
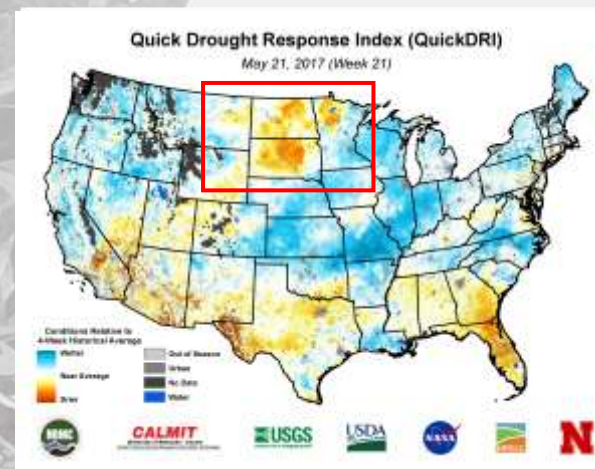
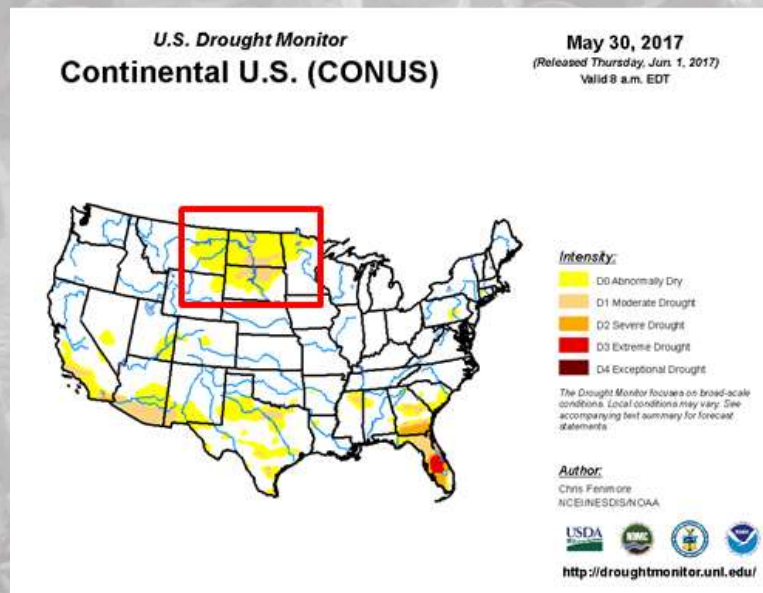
June 2017 Drought in Eastern Montana: Recommendations to the Governor's Drought and Water Supply Advisory Committee

A Drought Disaster Declaration is requested of the Governor for the following areas:

Hill, Blaine, Phillips, Valley, Daniels, Sheridan, Roosevelt, Richland, McCone, Garfield, Dawson, Prairie, Wibaux, Fallon, Carter, Custer, Powder River, Rosebud, Treasure, Petroleum, and Musselshell Counties, as well as the Fort Peck Indian Reservation.¹

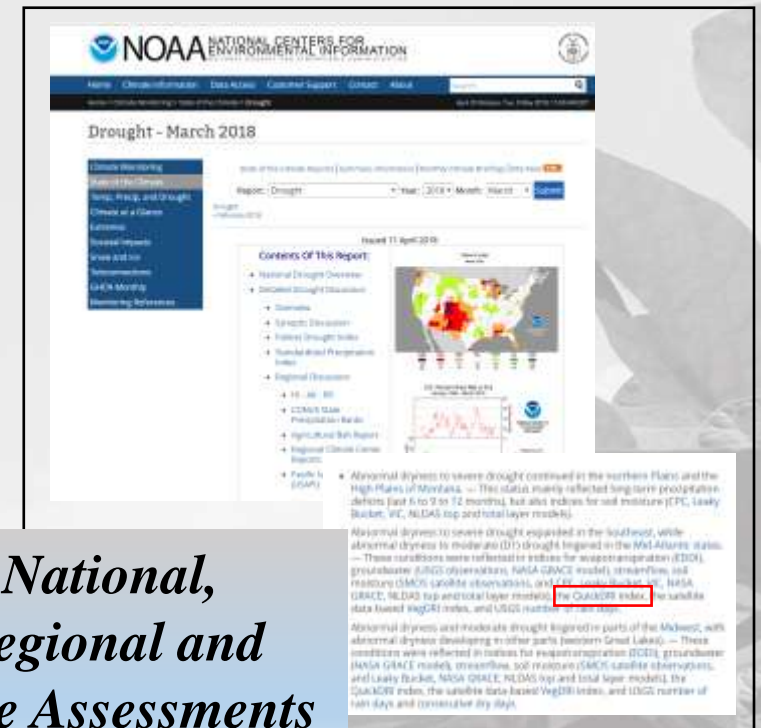
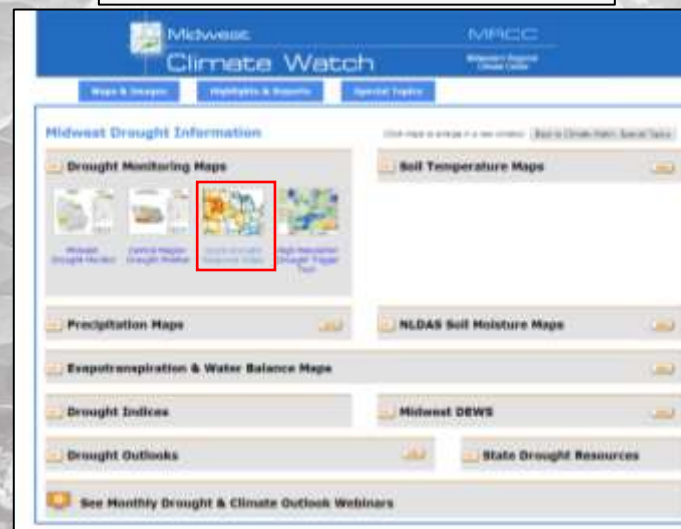
The following information was taken into account to make this recommendation:

.....newly developed Quick Drought Response Index (QuickDRI) showed that from May 28 to June 11, 2017, drought had developed quickly with soil temperatures reaching 70°F, topsoil moisture levels at 56% of normal, only 23% of emerged wheat being listed as good to excellent, cattle being sold, both yearlings and cow-calf pairs, indicating that producers are culling their herds, winter wheat being cut for hay instead of harvesting and the implementation of burn bans in North Dakota.

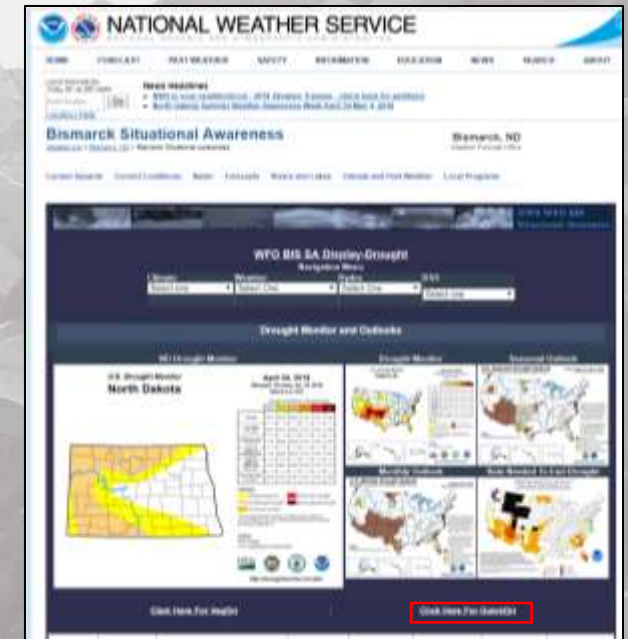


Other Applications of QuickDRI

Media



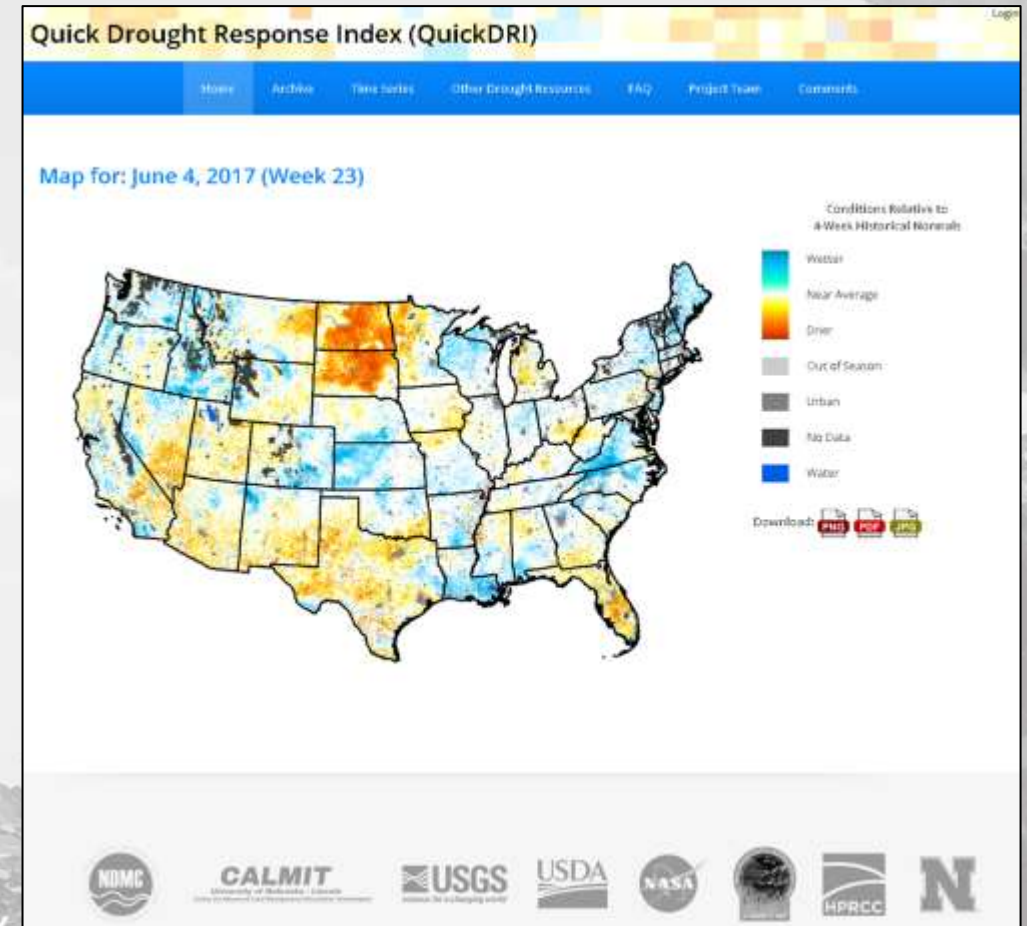
National, Regional and State Assessments



Operational QuickDRI Products

Current and historical QuickDRI data and maps distributed via the QuickDRI website

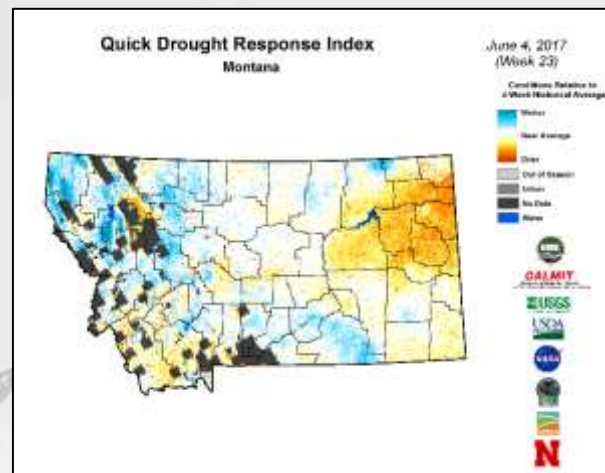
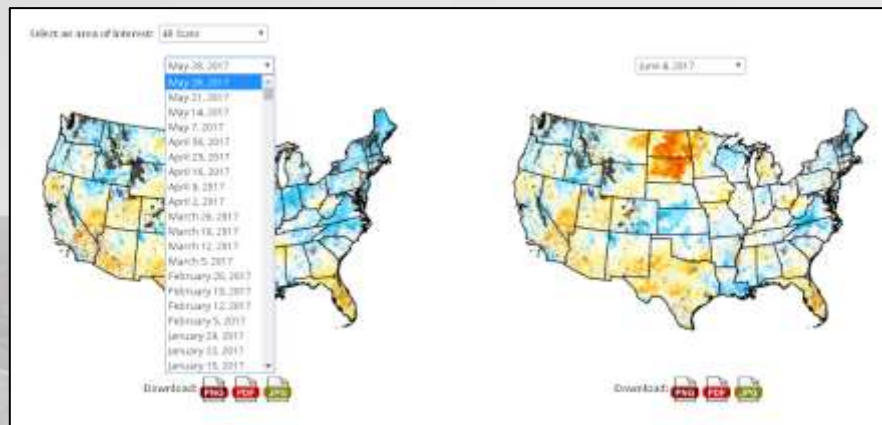
- **Weekly map updates**
- **4-km QuickDRI gridded data** for the continental United States
- **16+ year history of weekly maps** dating back to 2001
- **Value-added information products** available will include:
 1. **Current and historical maps** at national and state levels
 2. **Annual animations of QuickDRI maps** for each year in historical record
 3. **Suite of other current drought indicator maps** (e.g., soil moisture and evapotranspiration) to analyze in combination with the QuickDRI map.



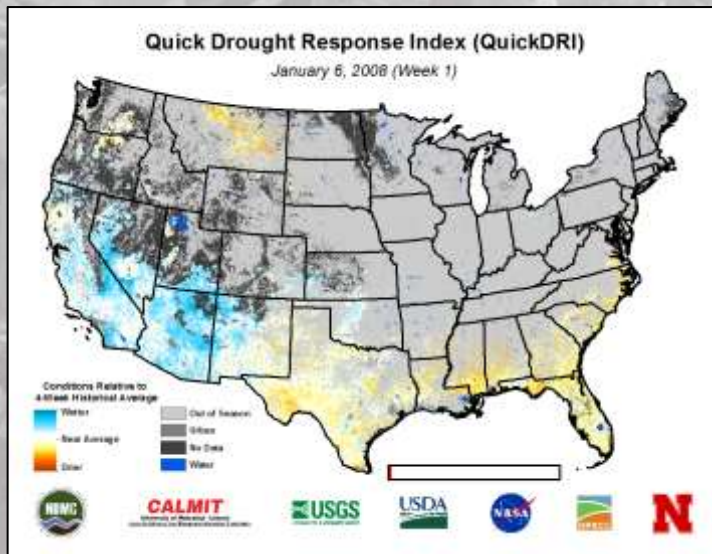
quickdri.unl.edu

Operational QuickDRI Products

Historical Map and Data Archive for Continental U.S. and Individual States



Annual Time-Series Map Animations



Frequently Asked Questions Section

Overview

A joint NASA-supported project team involving the National Drought Mitigation Center (NDMC) and Center for Advanced Land Management Information Technologies (CALMIT) at the University of Nebraska-Lincoln, U.S. Geological Survey (Earth Resources Observation and Science (EROS) Center, U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS), and NASA Goddard Space Flight Center (GSFC) has developed a drought monitoring tool called the Quick Drought Response Index (QuickDRI), which is tailored to detect short-term changes in rapid reevaluation of drought conditions through the integration of satellite, in-situ, and biophysical information.

QuickDRI is a geospatial tool that characterizes the intensification of extreme drought conditions patterns on a weekly basis across the continental United States (CONUS) as a 4-week gridded spatial indicator. The primary goal of QuickDRI is to serve as an "alarm" indicator of rapidly emerging events such as "flash drought" that manifest rapidly in the order of a few days to weeks, are often difficult to detect using traditional drought indicators, and can having devastating negative impacts on agriculture and natural resources.

QuickDRI information is designed to improve the spatial detail and timeliness of the U.S. Drought Monitor, which is used as a trigger by some of federal and state drought assistance programs (e.g., USDA Emergency and Foreign Programs), as well as the drought monitoring and planning activities of the National Integrated Drought Information System (NIDIS) regional drought early warning systems, state drought task forces, and other agricultural and natural resource drought management and response activities.

What does QuickDRI show?

QuickDRI represents a drought "alarm" indicator of emerging or rapidly changing drought conditions that can support drought severity assessment in combination with a detailed, longer-term analysis of drought indicators.

What drought categories correspond with the legend?

QuickDRI only presents the relative intensity of conditions on a gradient rather than individual drought categories. The QuickDRI gradient spans a range from stress intensification to normal to improvement. On one end, intensification of drought conditions may indicate when drought stress may be emerging or rapidly changing. The other end of the gradient shows when conditions are improving or becoming less severe as drought is not a problem. At the center of the range, stable conditions are occurring, where there is no marked drought intensification or improvement, which would be expected during time periods when seasonal precipitation is received and conditions are not excessively dry or wet.

What time period does QuickDRI consider when determining "normal" conditions?

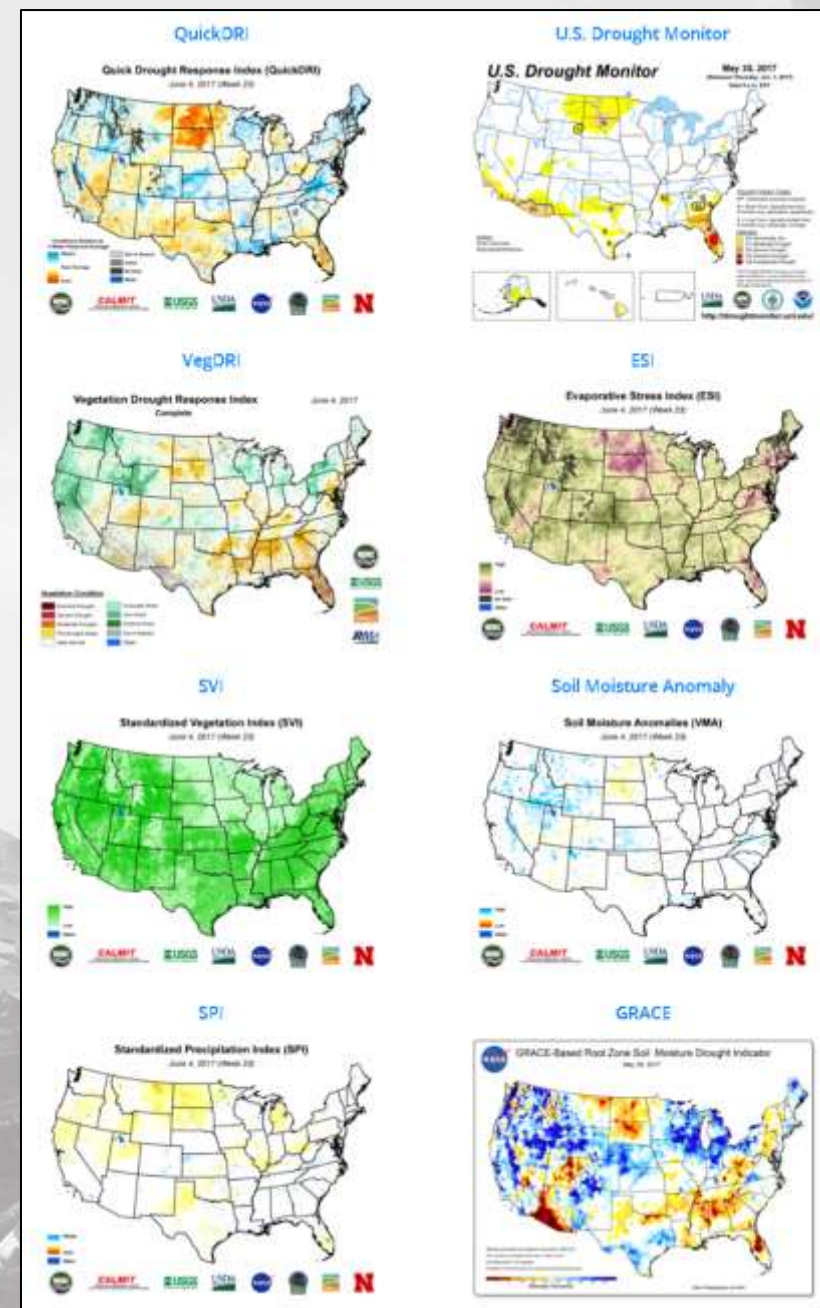
The normal period of record for QuickDRI model development is 2003-2012.

How is QuickDRI different from VegDRI?

QuickDRI looks at vegetation drought indicators over a short (4-week) timeframe to show the degree of environmental stress, whereas VegDRI looks at vegetation conditions over a longer (seasonal to 1-year) period.

In addition, some of the underlying datasets that go into the QuickDRI and VegDRI models are different. QuickDRI incorporated data that characterizes general vegetation conditions (NDVI based) and vegetation indices (e.g., vegetation indices) and other biophysical information (precipitation, 1-month evapotranspiration, and soil moisture). VegDRI, on the other hand, uses vegetation indices (e.g., vegetation indices) and other biophysical information (precipitation, 1-month evapotranspiration, and soil moisture).

Other Drought Indicator Map Section

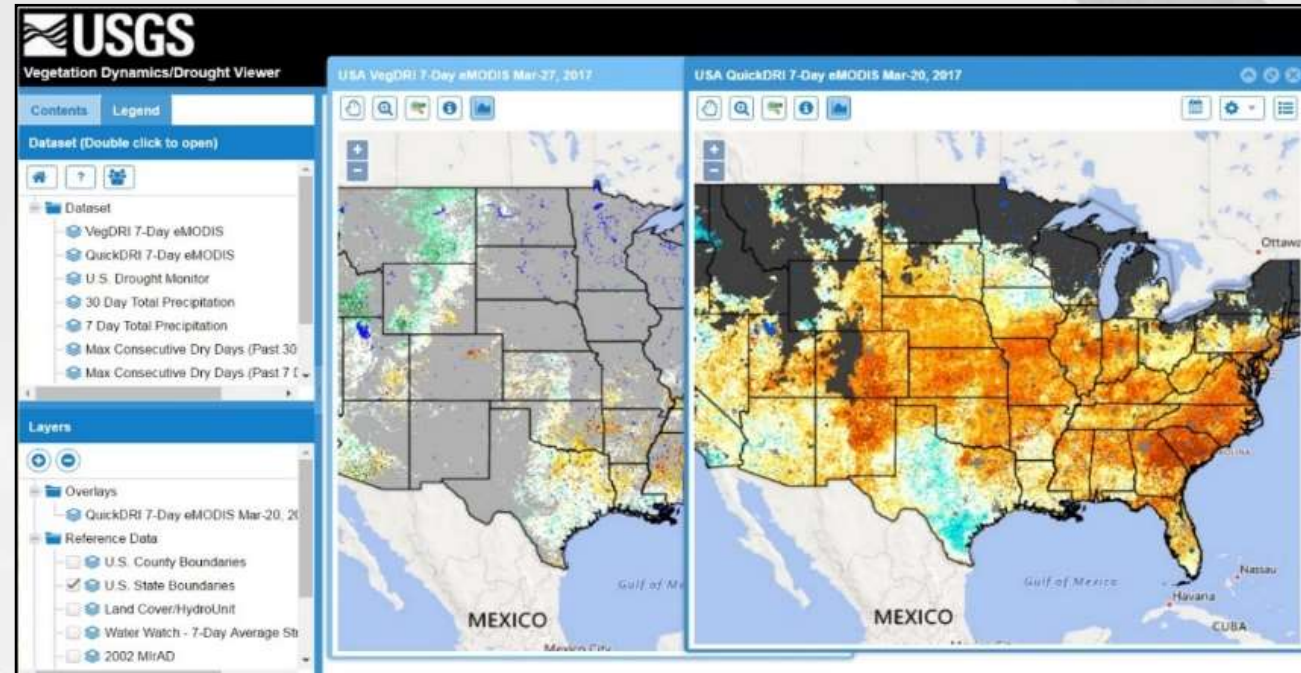


USGS Vegetation Dynamics / Drought Viewer

QuickDRI gridded data is displayed in an interactive map viewer with other drought indicators and geospatial data layers:

- VegDRI
- Total precipitation
- Dry day period
- Vegetation health
- Land cover and land use

Gridded, 1-km QuickDRI data also distributed via a web services.



vegdiri.cr.usgs.gov/viewer/

Current and Future Work

- **Additional statistical analysis of historical QuickDRI responses** over the continental U.S. to characterize the seasonal and regional performance of the index.
- **Evaluate the QuickDRI information for other applications.**
 - Wildfire risk with the Texas Forest Service
 - Use in state drought plans – State of Massachusetts
 - Watershed-level water resource management
- **Examine the relationship between the QuickDRI response and reported drought impacts** to determine how it might be used to establish drought response ‘triggers’.
 - Evaluating the QuickDRI response with ground-based agricultural producer observations and impacts for the 2017 drought in the Dakotas and Montana.
- **Explore the use of new remotely sensed data sets for integration into QuickDRI**
 - Vapor pressure deficit – NASA AIRS sensor
 - Root-zone soil moisture – NASA GRACE Follow-on Mission
 - Short-term soil moisture trends – NASA Soil Moisture Active Passive (SMAP) mission
 - Chlorophyll fluorescence – European Global Ozone Monitoring Experiment 2 (GOME-2) and the upcoming European Space Agency (ESA) Fluorescence Explorer (FLEX) mission

For more information about QuickDRI, please visit:

<http://quickdri.unl.edu/>

or contact

Brian Wardlow

bwardlow2@unl.edu

